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RED CEDAR CHESTS AS PROTECTORS AGAINST MOTH DAMAGE.

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INTRODUCTORY.

Chests made of red cedar have the reputation of protecting clothing stored in them from the ravages of clothes moths. There has been, however, much difference of opinion as to whether the supposed protection comes from the tightness of the chests which excludes moths, or from an inherent quality of the wood that actually kills moths accidentally placed in them with fabrics and furs. Considering the centuries-old belief, entertained among so many peoples, that this odoriferous cedar affords protection against moth attack, surprisingly little has been done to determine whether or not chests made of this wood are efficacious. Working with the southern or webbing clothes moth, *Tineola biselliella* Hummel (Pl. II, A), the writers undertook a comprehensive study of the effect of red cedar chests upon adults, eggs, and larvæ to ascertain whether or not chests made of red cedar could be considered as adequate protection of clothing against these insects.

SOURCE, DISTRIBUTION, AND DESCRIPTION OF RED CEDAR.

Red cedar (*Juniperus virginiana*), commonly known as Tennessee or Virginia red cedar, is one of the most widely distributed coniferous trees of North America, occurring on dry hills or in deep swamps, sometimes attaining a height of 90 feet, but usually averaging 40 to 50 feet or less. The tree is distributed throughout all sections of the United States as far west as the Rocky Mountains, flourishing under various climatic conditions. It is most abundant, however, in the region from the Ohio River on the north to Florida on the south and from the Atlantic Ocean on the east to Arkansas on the west. In Tennessee, Virginia, and North Carolina the red cedar occurs in large areas of nearly pure forests known as "cedar breaks." In these sections the most extensive manufacture of cedar lumber is conducted.

In general, the red cedar is a straight tree, pyramidal in shape, becoming round-topped in old age, and has a tapering trunk and shreddy bark. The wood is light, close-grained, compact, and durable. The heartwood is red in color and strongly aromatic, while the sapwood is white and devoid of odor.

USES OF RED CEDAR.

The commercial use of the wood dates back to the seventeenth century. In 1632 Morton (*12, p. 49–54, pl. 45*),[1] in citing the trees that are found in New England, stated:

> Cedar, of this sorte there is abundaunce; and this wood was such as Salomon used for the building of that glorious Temple at Hierusalem. . . . This wood cutts red, and is good for bedsteads tables and chests, and may be placed in the Catalogue of Commodities.

In 1682 Gent (*4, p. 63*), in describing the resources of South Carolina, mentioned the presence in that State of odoriferous and fragrant woods, among them being the sweet-scented cedar and cypress, from both of which were made boxes, chests, tables, and cabinets. He further stated that:

> The Dust and Shavings of Cedar, laid amongst Linnen or Woollen, destroys the Moth and all Verminous Insects; It never rots, breeding no worm, by which many other Woods are consumed and destroyed.

In 1757 Peter Kalm (*7, p. 264*), in a report of his early travels in North America, mentioned red cedar as being prized for its durability.

In 1776 Hunter (*6*) stated that the timber was very valuable for many uses and possessed a bitter resin which prevented worms from attacking it. Later, in 1786, Lamarck (*9*) stated that the wood was much sought in America for carpentry, construction of vessels, woodwork, and different utensils, because it was filled with a bitter resin which prevented its destruction by worms. According to Bigelow (*1, p. 49–54, pl. 45*), in 1820, the wood—

> is principally employed for posts in fences, in which capacity it proves more durable than almost any species of wood used for the same purpose.

Loudon (*10, p. 848*), mentioned *Juniperus virginiana* as producing lumber which is "very odoriferous" and useful for cabinet making

[1] The figures (*italic*) in parentheses refer to "Literature cited," p. 14.

"as it is offensive to most insects." In 1838 he stated (*11*) that on account of its strength and durability the barriers of the sidewalks of the streets of Philadelphia were made of this wood, which was also used for making tubs, stopcocks, and coffins.

In presenting certain historical data of New York, O'Callaghan (*13, p. 40*), in all probability referring to red cedar, stated:

> There is Red-wood which being burned, smells very agreeable; when men sit by the fire on benches made from it, the whole house is perfumed by it.

Porcher (*14, p. 588–589*), in 1869, made the statement that—

> Cedar boxes are not infested by insects, moths, etc., and are used for storing away woollens. The leaves also prevent the attacks of insects when spread over cloth.

Further reference to the use of red cedar against insects was made by Emerson (*3, p. 120*) in 1875, to the effect that the agreeable and permanent odor of the wood recommends it for certain uses, such as pencils and the bottoms of boxes and drawers, the aroma making it a safeguard against insects. Similarly, it was stated by Curtis (*2, p. 118–119*) that boxes and cabinets made of red cedar wood were exempt from insects on account of its odor being offensive to them. Hansen (*5, p. 298–299*) stated that the wood possessed much economic value, being durable and free from the attacks of insects.

It was reported by Sargent (*15*) in 1895 that the wood of red cedar is highly resistant to decay and that insects do not molest it. It is further stated by the same author that moths flee from the pungent odor, and that every good housekeeper knows the value of a red cedar chest or a closet lined with this wood. The following year (*16*) he also asserted that the wood is very fragrant and easily worked, being used largely for fence posts, railway ties, sills, cabinets, lead pencils, the interior finish of houses, and for protecting woolens against the attack of moths.

According to Kent (*8*) the wood is highly resistant to decay by water and is therefore valuable for fence posts and other purposes where it comes into contact with moist soil or water. This author also states that moths flee from the pungent odor, and that a chest of red cedar or a closet lined with red cedar wood affords an efficient protection against their inroads. It is also reported that the waste at pencil factories is used to manufacture a paper which has been found useful for wrapping wools, furs, and other articles likely to be injured by moths.

It is stated by White (*18*) that the heartwood of the cedar constitutes the portion of the tree which is used extensively for pencil making. For this purpose it is essential to have the straight-grained red wood, free from knots.

On account of the lack of cedar logs of any great size and the need for the heartwood free from knots, old logs and fence rails are being used for the manufacture of pencil slats.

Within the last 15 years red cedar has been used in constantly increasing quantities in the manufacture of cedar chests. All of the red heartwood and part of the white sapwood is utilized for this purpose. The industry has grown very rapidly and at the present time red cedar chests are recognized as staple articles of furniture. These chests combine ornamental beauty with utility as receptacles for the storage of clothing. Their beautiful and attractive appear-

ance is due to the striations of red heartwood and white sapwood interspersed with the deeper-colored circular or oval knots. By means of the firm construction, the extremely tight-fitting cover, and the heavily-varnished exterior, the odor of the wood is retained within the chest. In this connection it may be of interest to state that during a recent pilgrimage to "The Hermitage," the plantation of Andrew Jackson, located near Nashville, Tenn., in the heart of the red cedar belt, there was seen a hand-made cedar chest which was considerably over a hundred years old. It is reported that this chest still retains the full fragrance or aroma of the cedar, and doubtless from the standpoint of odor still possesses its original efficiency.

AROMA OF RED CEDAR.

The persistent, characteristic odor of red cedar, which has been credited with possessing the property of destroying the clothes moth, or at least preventing damage by it, is due to a volatile oil which forms 1 to 2 per cent of the wood. The pure heartwood, or the red wood, contains from 2 to 4 per cent of this volatile oil, which is pale yellowish-brown in color and possesses an agreeable, persistent odor. The principal constituents of the oil are the alcohol cedrol, or cedrol camphor, which can be separated from the oil in the form of crystals; the sesquiterpene alcohol cedrenol; and the sesquiterpene cedrene. The characteristic odor is probably due to the former two compounds. It is stated that the oil possesses antiseptic properties, but little is known regarding its insecticidal properties.

CEDAR CHEST EXPERIMENTS.

The only experimental work previously recorded was by Scott, Abbott, and Dudley, reported (*17*) upon in 1918. These authors, working with the southern, or webbing, clothes moth (*Tineola biselliella*) and one cedar chest, the history of which was not known, concluded that a red cedar chest killed adults and newly hatched larvæ, but had no effect on larvæ half grown or larger. With these conclusions the writers, working also with *Tineola biselliella*, agree in the main, although none of the chests used by them in their work either killed adult moths or prevented them from laying eggs.

In the experimental work recorded below, nine red cedar chests, with a capacity of from 3.9 to 5.5 cubic feet, were obtained newly made in 1920 from representative manufacturers. These chests (Pl. I) were from regular stock and were shipped direct from the factory. They were of $\frac{7}{8}$-inch lumber, had the usual attractive finish, and were of the average run of chests placed upon the retail market.

EFFECT UPON ADULT MOTHS.

Scott, Abbott, and Dudley state (*17*) that 70 adult moths were introduced into a cedar chest and that an examination two months after the last adults were introduced showed that "all had been killed and that no eggs or larvæ were present." This conclusion regarding the effect of a cedar chest upon adult life is not justified since in longevity experiments on file adult clothes moths have never lived two months and seldom so long as 30 days. The same authors state also that 30 adults and a supply of flannel were added to the same chest two years later. Observations made nine weeks after the

NINE CEDAR CHESTS, RANGING IN CAPACITY FROM 3.9 CUBIC FEET TO 5.5 CUBIC FEET, USED IN EXPERIMENTAL WORK.

experiment was started revealed no living adults, no eggs, and no larvæ. In a trunk serving as a check to which the same number of adults were added at the same time, more than 50 live larvæ were counted on the flannel at the close of the experiment. This is the only reference in literature to the effect of cedar chests upon adult clothes moths.

The following data indicate that the cedar chests used by the writers have little practical effect upon the length of life or upon the egg-laying of adult moths. The data are incomplete, but sufficient to prove that adults developing in chests from larvæ transforming to the pupa stage in the chests can live at least 10 days, which in longevity experiments conducted as checks was about the average length of life under normal conditions. It is possible, moreover, for such adults to mate and deposit eggs that will hatch.

On June 17, 1920, 15 adults (sex undetermined) newly emerged in chests were placed with cloth in Chest 1. On June 26, 11 were alive and eggs had been laid. On June 28 all adults were dead, and 123 eggs had been laid; by July 6 all eggs had hatched. Twenty larvæ removed from the chests on June 28 continued to develop normally outside the chest.

On July 2, 1920, 7 adults (sex undetermined) emerging in the laboratory were introduced with cloth into Chest 2. Adults were found depositing eggs on July 3. Examination on July 17 showed 18 eggs had been deposited, 14 having hatched. One adult was barely alive, being too feeble to crawl.

On March 28, 1921, one group of three virgin moths and another group of five, emerging within cedar chests, were placed with cloth in Chest 1. Examination on May 31, 1921, showed all adults dead, and 53 and 30 eggs deposited, respectively. These eggs were infertile and did not hatch.

On March 30, 1921, 6 adults (sex undetermined) found emerged in cedar chests were placed the same day in Chest 2, with cloth. Examination on April 28 showed 1 adult alive, about 80 eggs laid and hatched, and living and dead larvæ.

EFFECT UPON EGGS.

Cedar chests have no apparent effect upon clothes-moth eggs. This is true of eggs deposited in the chests by females emerging in the chests or by females emerging in the laboratory and placed in the chests for oviposition, and of eggs laid outside of chests and later introduced into them. Scott, Abbott, and Dudley (*17*) state that an examination of a piece of flannel containing many clothes-moth eggs 23 days after it was placed in a cedar chest showed that practically all the eggs were hatched but that the resulting larvæ had died almost immediately. A duplicate test by them gave identical results.

On June 5 and 18, and July 10, 1920, and February 12, March 3, 10, and 28, April 27, May 7 and 14, and June 6, 1921, an average of about 300 eggs, ranging in age from 1 to 7 days, were introduced into each of four cedar chests. Of 50 experiments conducted to determine the effect of chests upon the egg vitality the following 10 are recorded as typical:

(1) Twenty-six adults (sex undetermined) were found March 28, 1921, having developed in cedar chests from larvæ introduced into

the chests January 21, 1921. The adults were placed in a large vial with cloth and immediately replaced in Chest No. 1. Examination May 11 proved that about 200 eggs had been deposited and practically all eggs had hatched.

(2) Four adults (sex undetermined) found in chests April 8, 1921, developed from larvæ introduced into the chests January 1, 1921, were placed with cloth in the chests. Examination April 30 determined that 43 eggs had been deposited and all of them had hatched.

(3) On February 12, 1921, 24, 30, 22, and 14 eggs, deposited, respectively, on February 9–12, 10–12, 11–12, and 12, were placed in Chest 2. Examination on March 2 determined all eggs to have hatched.

(4) On March 10, 1921, 54, 106, 52, 25, and 45 eggs, deposited, respectively, on March 3–5, 5–7, 7–8, 8–9, and 9–10, were placed in Chest 2. Examination on March 17 determined that all eggs had hatched except 46, and of these, 40 were those deposited on March 9–10. Of 292 eggs deposited March 12–14 and held as checks in the laboratory outside of chests, 148 hatched on March 21–22 and 144 on March 22–23. A second examination on March 30 determined all eggs hatched. Of 32 eggs deposited March 2–3 and held as checks in laboratory outside chests, 20 hatched on March 14 (no further observation made).

(5) On April 27, 1921, 232 and 102 eggs deposited April 24–27 and April 26–27, respectively, were placed in Chest 1. Examination on May 11 determined that all eggs had hatched. Of 284 eggs deposited on April 24–27 and held in the laboratory outside of the chests, 100 hatched April 30 and 184 between April 30 and May 3.

(6) On May 14, 1921, 160, 53, 75, 69, 38, and 94 eggs deposited on May 7–9, 9–10, 10–11, 11–12, 12–13, and 13–14, were placed in Chest 3. Examination on May 19 determined that eggs deposited on May 7–11 had hatched; those deposited on May 10–11 were just hatching and the larvæ had not yet had an opportunity to feed. The 69, 38, and 94 eggs deposited between May 11 and 14 were not hatched but were found hatched when examined May 31. Of 336 eggs deposited May 5–6, 1921, and held as checks in the laboratory outside of chests, 111 hatched May 13, 146 on May 14, and 79 on May 18.

(7) On June 6, 1921, 28, 51, 32, 12, and 91 eggs deposited, respectively, on June 1–2, 2–3, 3–4, 4–5, and 5–6, were placed in Chest No. 1. Examination on July 7 determined that all eggs had hatched.

(8) On May 14, 1921, 138, 60, 61, 43, 36, and 19 deposited, respectively, on May 7–9, 9–10, 10–11, 11–12, 12–13, and 13–14, were introduced in Chest No. 1. The eggs were examined on May 17, those deposited on May 7–9 and 9–10 were still hatching, while those deposited between May 11 and 14 were unhatched. Examination made on May 19 determined that all eggs had hatched which were deposited between May 7 and 11 and hatching had begun among those deposited May 11–12. No hatching was noted among eggs deposited May 12–14. Examination on May 31 showed that all eggs had hatched. Of 151 eggs deposited May 16–17 and held as checks in the laboratory outside of chests, 13 hatched on May 24 and 138 on May 25.

(9) On May 7, 1921, 36, 38, and 39 eggs deposited, respectively, on May 4–5, 5–6, and 6–7, were introduced into Chest No. 4. Examination on May 12 determined that eggs deposited on May 4–5 had already hatched, but the larvæ had not yet fed; eggs deposited on

May 5–7 were still unhatched. Examination May 21 determined that all eggs had hatched. Of 739 eggs deposited May 6–7 and held as checks in the laboratory outside of chests, 465 were hatched May 14 and 274 on May 15.

(10) On May 7, 1921, 46, 13, and 107 eggs deposited, respectively, May 4–5, 5–6, and 6–7, were introduced in Chest No. 2. Examination on May 11 determined that 1 egg only of those deposited May 4–5 had hatched. Examination on May 21 showed that all eggs had hatched. Of 267 eggs deposited May 4–5 and held as checks in the laboratory outside of chests, 89 were hatched May 12 and 178 on May 13. Of 336 deposited May 5–6 and held as checks in the laboratory outside of chests, 111 were hatched on July 13, 146 on May 14, and 79 on May 18.

EFFECT UPON LARVÆ.

The effect of cedar chests upon larvæ of clothes moths varies with the age and growth attained by the larvæ when they are subjected to the action of the chests. It has been taken for granted in popular entomological literature that larvæ become fully grown during warm weather in from 4 to 10 weeks, but there are no authentic cases recorded of clothes moths actually reared from egg to adult at any season of the year in less than four months.

Observations made in the laboratory at Washington, D. C., during 1920 and 1921 indicate that no definite statement can be made concerning the time it will take clothes-moth larvæ to become fully grown, since their growth varies tremendously when they are fed upon the same material or upon different materials.

These statements seem necessary to indicate to the reader why one can not judge the age of a clothes-moth larva by its size. Clothes-moth larvæ do not mature as fast as has been thought. It is well to understand that larvæ that have become one-half to full grown, regardless of the time required to attain this growth, have been able to cause so much damage and to leave behind them in their feeding so much webbing (Pl. II, B) and sandlike frass that their presence can be detected by a casual examination of the affected garments. Exception is made of certain fur garments where the feeding larvæ lie buried beneath the fur close to the skin; but even in this case the falling of the severed fur will readily reveal damage.

Garments should not be placed in chests without first having been beaten, brushed, and sunned to remove the larvæ. This treatment, advised as a preliminary for all materials intended for storage in cedar chests, if painstakingly done should remove even younger and smaller larvæ. Any larvæ remaining, however, and entering the chests with the clothing are apt to be very young or very small. This is a most important fact, as cedar chests kill only very young or small larvæ.

Since cedar chests can not be depended upon to kill half to full grown larvæ, such articles as balls of yarn, floor skins backed with woolen cloth, infested pillows stuffed with hair or feathers, and similar articles, all portions of which can not be brushed on all sides, might better be treated by fumigation or other methods to kill older larvæ before being placed in cedar chests. Otherwise these articles may be fed upon somewhat in cedar chests by the older larvæ, until they have transformed into moths, but will be protected thereafter.

Cedar Chests Do Not Kill One-Half to Full Grown Larvæ.

Cedar chests can not be depended upon to kill larvæ after they are half to full grown, or after they are about three or four months old. To be sure, many of these older larvæ die in the chests, but it is not possible to tell whether their death is caused by the chests or is the result of the high mortality obtaining among any lot of clothes-moth larvæ used in experimental work. The only work done indicating the effect of cedar chests upon the older larvæ is that of Scott, Abbott, and Dudley (*17*). They say:

> In 1915 flannel was placed in this chest, and 10 one-half to three-fourths grown larvæ were added every two weeks until a total of 60 was reached. Examination made two months after the last addition of larvæ showed 7 live larvæ; 36 larvæ had died and 17 had pupated. Of the 17 pupæ 2 died in the pupa stage and 15 emerged as moths, but died before any eggs were laid. The flannel had been fed upon considerably, but was not badly eaten.
>
> Two years later (1917) this experiment was duplicated by adding 25 one-half to three-fourths grown larvæ at one time and allowing the experiment to run 33 days. The results were almost identical with those of the first experiment.

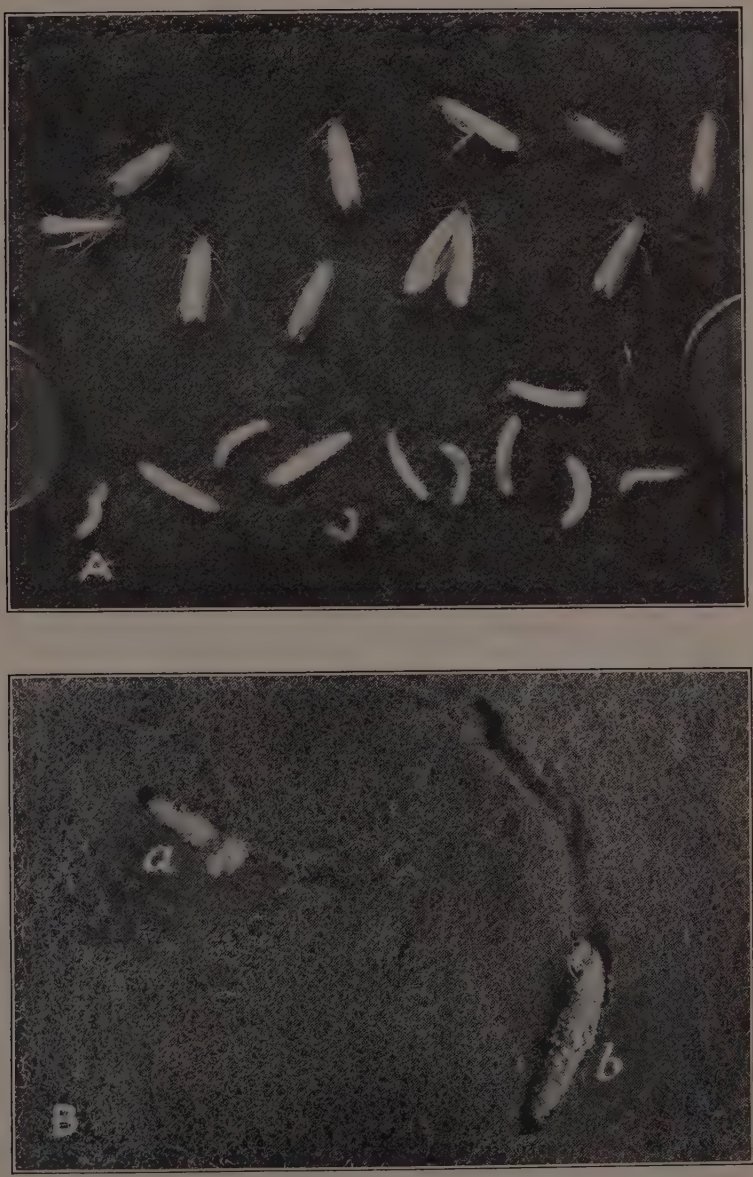
On January 31, 1921, 24 well-grown larvæ were placed in a chest upon a high-grade blue-serge cloth, and 35 others upon a felt pillow top. Both lots of larvæ caused serious damage to the goods by March 2 (Pl. II, fig. 2). During an examination made on that date it was found that of the 50 larvæ 18 were still in the larva stage and alive, 6 had died, 9 had transformed to the pupa stage, and 13 had emerged as adults; the remaining larvæ had eaten through the cloth and escaped into the clothing filling the chest.

Of 100 larvæ (40 well grown, 40 half grown, and 20 very small, but fully four months old) placed on January 31, 1921, in Chest 2 in pill boxes, 13 had emerged as moths by March 2, 16 emerged between March 2 and 17, 19 between March 17 and April 30, and 12 between April 30 and May 11; the remaining 40 died as larvæ or pupæ.

Of 60 well-grown larvæ placed in Chest 1 on January 31, 1921, 2 had transformed to the adult stage by March 2, 9 became adults between March 2 and 17, and 14 between March 17 and May 11; the remaining 35 died either as larvæ or pupæ. Of 50 half to full-grown larvæ placed in Chest 3 on January 31, 13 emerged as adults by March 2. Of the 2, 13, and 13 adults found emerged in Chests 1, 2, and 3 on March 2, developing from larvæ placed in chests on January 31, 1921, 2, 10, and 5, respectively, were alive, while 0, 3, and 8, respectively, were dead.

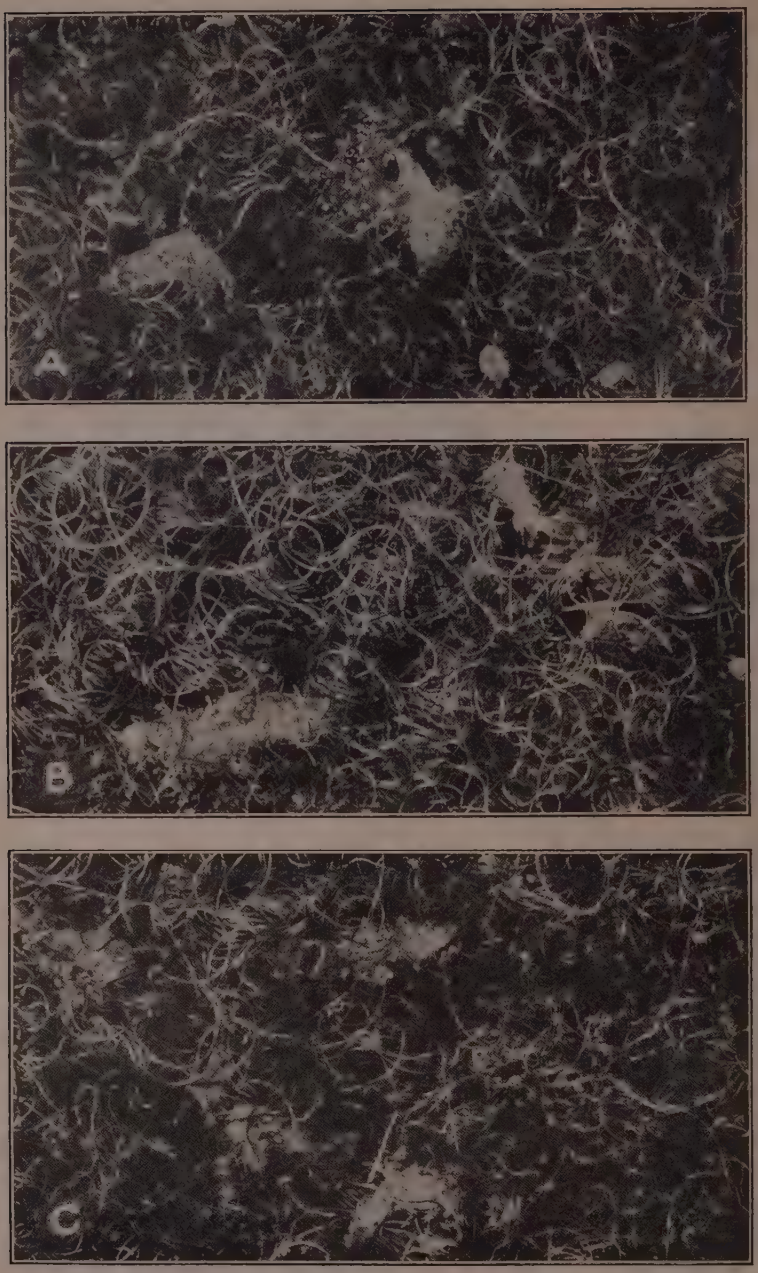
Half to full-grown larvæ placed in Chest 2 on February 11, 1921, developed into adults during the period March 17 to July 27; 1, 1, 8, 6, 4, 3, 7, and 1 being found during examinations made on March 17, 30, April 30, May 11, June 6, July 7, 15, and 27, respectively. The adult found emerged during the July 27 examination, approximately 5½ months after the larvæ were placed in the chest, was alive, very active, and appeared no different in general vitality from others emerging under normal laboratory conditions. One larva of this lot was found alive, normal to all appearances, and very well grown, on July 27, but had died by August 3.

Half to full-grown larvæ placed in Chest 1 on February 11, 1921, developed into adults during the period March 17 to July 23; 1, 8, 3,



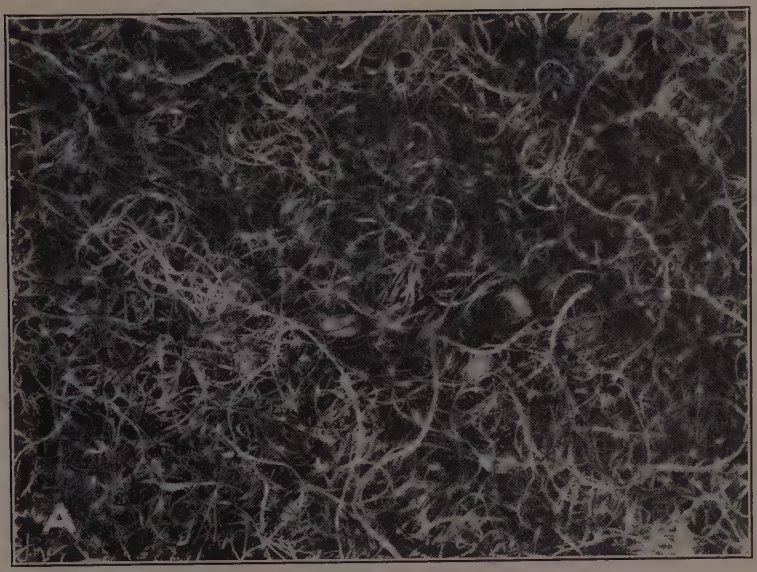
RED CEDAR CHESTS AS PROTECTORS AGAINST MOTH DAMAGE.

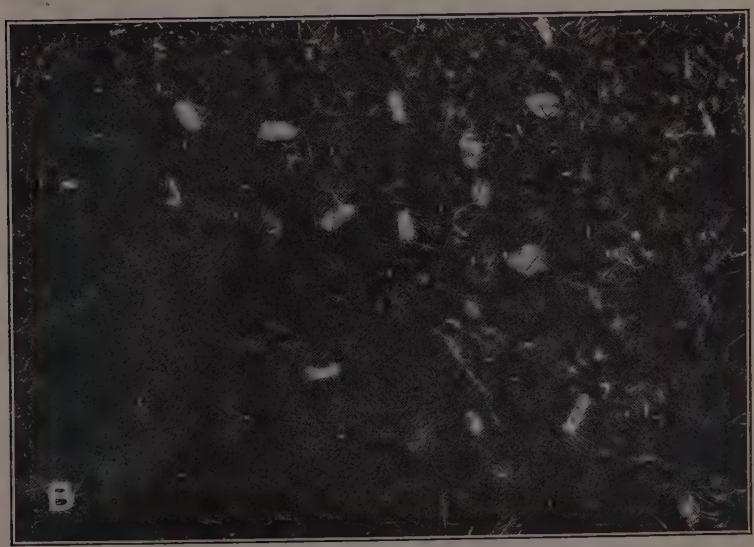
A, Adults and well-grown larvæ of *Tineola bisselliella*. It is only the larva or worm that damages fabrics. Magnified about 2 diameters. B, Felt pillow top damaged in cedar chest by half to fully grown larvæ of the clothes moth. Beside the damaged portions of goods, note, at *a* and *b*, the whitish tubes of silken threads in which the larvæ secrete themselves while resting. Magnified 2 diameters.



CHEAP GRADE OF ARMY CLOTH SHOWING VARIOUS DEGREES OF WEBBING AND SLIGHT FEEDING BY YOUNG LARVAE OF CLOTHES MOTHS HATCHING INSIDE CHESTS.

The white areas are silken tubes spun by the newly hatched larvæ in which they rest and from the ends of which they feed upon the cloth. A, B, and C represent the maximum amount of webbing ever noted by the authors in any chest. Magnified 12 diameters.





RED CEDAR CHESTS AS PROTECTORS AGAINST MOTH DAMAGE.

A, Eggshells of the clothes moth partially hidden in loosely woven army cloth. Although these eggs have hatched the young larvæ were killed in the chest before they could spin webs or feed upon the fabric. Magnified 12 diameters. B, High grade woolen cloth of moderately close weave. Note eggshells and dead newly hatched larvæ of clothes moths. Larvæ were killed in the chest before they spun webs or fed upon fabric. Magnified about 12 diameters.

WOOLEN CLOTH TAKEN FROM CEDAR CHEST, SHOWING HATCHED EGGS, DEAD YOUNG LARVAE, AND A VERY SLIGHT WEBBING MADE BY THE LARVAE BEFORE DEATH.

This sample of cloth, like those of Plate IV, is not injured by the larvæ of the clothes moth. The circle indicates a dead larva; the arrow, an eggshell.

5, and 2 being found during examinations made March 17, May 11, June 6, July 7, and July 23, respectively.

Half to full-grown larvæ placed in Chest 3 on February 11, 1921, developed as adults during the period March 17 to June 6; 1, 2, 3, 2, and 1 moths being found during the examinations made on March 17, May 12, May 31, June 6, and July 7.

A miscellaneous lot of 100 larvæ, apparently half to full grown, were placed in Chest 1 on April 9, 1921. Examinations made on May 11, May 31, July 7, July 23, and August 3 showed that there had emerged 53, 2, 7, 0, and 0 adults, respectively. Of 100 larvæ of like age placed on April 9, 1921, in Chest 2, 42, 4, 2, 0, 0, and 0 adults were found emerged on April 30, May 11, June 6, July 7, July 23, and August 3, respectively.

Cedar Chests Kill Young Larvæ.

Cedar chests have a pronounced killing effect upon young clothes-moth larvæ. Of the larvæ hatching within cedar chests from the 2,074 eggs recorded under the discussion of the effect of chests upon the vitality of the eggs, none were found alive during examinations made one month from the date the eggs were placed in the chests. Exception must be made for one larva hatching from eggs laid April 26–27, which were placed in Chest 3 on April 27, 1921, that was found alive during examinations made on May 12, 21, and 31, but which was dead by June 2.

Practically all larvæ hatching within the chests died within two weeks after hatching and a surprisingly large number died within two or three days of hatching. Exact data on this point are lacking because to obtain them would require the chests to be opened so frequently that their killing power would be weakened. Thus Chest 2 had been opened more often than Chests 1, 3, and 4 just previous to May 21 examination recorded in Table I, with the evident result that its effect upon even very young larvæ was quite seriously affected. Scott, Abbott, and Dudley say (*17*) that larvæ hatching in chests "died almost immediately." As their examination was made 23 days after the eggs were placed in the chest and as their work was done during warm weather, when the egg stage ranges from 4 to 8 days, their statement should be interpreted to mean that the larvæ died without spinning webs or leaving signs of feeding. The practical point to keep in mind is that larvæ hatching within chests did not as a rule feed (Pl. IV and V) upon the cloth, and when they did, the damage done (Pl. III) would not be observed by the average person.

While the statements made concerning larvæ hatching within the chests from eggs placed there can not be as exact as could be wished because of variations in the length of the egg stage, the age of larvæ recorded in Tables I and II is definitely known and can be compared with larvæ accidentally introduced in clothing into chests. These larvæ hatched in the laboratory and were placed in chests at the ages indicated. In these tables are recorded data secured from each of four chests grouped according to the age of the larvæ and the date of examination. The numbers of the chests refer to the same chests in both tables. It will be seen that larvæ hatching outside the chests and later introduced into the chests do not die immediately,

but may linger along for a considerable number of days. Two larvæ, which were 2 days old when placed in a chest, were still alive (Table II) after 31 days in the chest, but were found dead when examined 6 days later. The majority of the very young larvæ die by the end of the first or second week, without causing damage. The greater resistance of the older larvæ is clearly demonstrated by the data. One 2½-month-old larva and one 2-month-old larva survived in the chest for over 2 months. Few people should have occasion to place in chests clothing containing larvæ over 1 month old.

TABLE I.—*Effect of four cedar chests upon 520 larvæ ranging in age from 1 day to 3 months, placed in chests on May 14, 1921.*

Age on entering chest.	Chest No.	Date and result of examinations.											
		May 21.		May 31.		June 6.		July 7.		July 23.		July 27.	
		Alive.	Dead.	Alive.	Dead.	Alive.	Dead.	Alive.	Dead.	Alive.	Dead.	Alive.	Dead.
3 months	1	10	0	6	4	4	6	2	8	0	10	.....	.....
	2	[1] 10	0	6	4	3	7	0	10	.....	.....	.....	.....
	3	10	0	6	4	.....	.....	0	10	.....	.....	.....	.....
	4	10	0	5	5	3	7	0	10	.....	.....	.....	.....
2½ months	1	10	0	9	1	8	2	1	9	1	9	0	10
	2	10	0	8	2	7	3	1	9	0	10	.....	.....
	3	10	0	8	2	.....	.....	0	10	.....	.....	.....	.....
	4	10	0	6	4	3	7	0	10	.....	.....	.....	.....
2 months	1	10	0	9	1	7	3	0	10	.....	.....	.....	.....
	2	10	0	8	2	7	3	[3] 3	7	1	9	0	10
	3	10	0	9	1	8	2	0	10	.....	.....	.....	.....
	4	10	0	10	0	9	1	1	9	0	10	.....	.....
1½ months	1	10	0	9	1	7	3	0	10	.....	.....	.....	.....
	2	10	0	10	0	9	1	[4] 2	8	0	10	.....	.....
	3	10	0	10	0	8	2	1	9	0	10	.....	.....
	4	10	0	9	1	8	2	0	10	.....	.....	.....	.....
1 month	1	10	0	10	0	10	0	1	9	0	10	.....	.....
	2	10	0	8	2	8	2	3	7	0	10	.....	.....
	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3 weeks	1	10	0	3	7	2	8	0	10	.....	.....	.....	.....
	2	10	0	7	3	5	5	0	10	.....	.....	.....	.....
	3	10	0	6	4	2	8	0	10	.....	.....	.....	.....
	4	10	0	5	5	3	7	0	10	.....	.....	.....	.....
2 weeks	1	8	2	3	7	2	8	0	10	.....	.....	.....	.....
	2	10	0	4	6	0	[2] 10	0	10	.....	.....	.....	.....
	3	9	11	3	17	2	18	0	20	.....	.....	.....	.....
	4	10	0	1	9	0	10	.....	.....	.....	.....	.....	.....
11 days	1	0	10	0	10	0	10	.....	.....	.....	.....	.....	.....
	2	10	0	2	8	0	10	.....	.....	.....	.....	.....	.....
	3	8	2	6	4	2	8	0	10	.....	.....	.....	.....
	4	0	10	6	4	0	10	.....	.....	.....	.....	.....	.....
8 days	1	2	8	2	8	0	10	.....	.....	.....	.....	.....	.....
	2	10	0	4	6	0	10	.....	.....	.....	.....	.....	.....
	3	3	7	1	9	0	10	.....	.....	.....	.....	.....	.....
	4	6	4	3	7	0	10	.....	.....	.....	.....	.....	.....
3 days	1	1	9	0	10	.....	.....	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	3	8	2	2	8	0	10	.....	.....	.....	.....	.....	.....
	4	7	3	2	8	0	10	.....	.....	.....	.....	.....	.....
2 days	1	0	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2	20	0	2	18	0	20	.....	.....	.....	.....	.....	.....
	3	3	7	0	10	.....	.....	.....	.....	.....	.....	.....	.....
	4	4	6	0	10	.....	.....	.....	.....	.....	.....	.....	.....
1 day	1	0	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2	20	0	1	19	0	20	.....	.....	.....	.....	.....	.....
	3	5	5	0	10	.....	.....	.....	.....	.....	.....	.....	.....
	4	4	6	1	9	0	10	.....	.....	.....	.....	.....	.....
	1	0	8	0	10	.....	.....	.....	.....	.....	.....	.....	.....
	2	10	0	0	10	.....	.....	.....	.....	.....	.....	.....	.....
	3	.....	.....	0	10	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	.....	2	8	0	10	.....	.....	.....	.....	.....	.....

[1] Examination made May 7, 1921, showed no mortality among larvæ placed in chests Apr. 30.
[2] Thoroughly active and normal.
[3] Alive but on point of death.
[4] Larvæ doubtfully dead.

TABLE II.—*Effect of four cedar chests upon 520 larvæ ranging in age from 1 to 28 days, placed in chests Apr. 30, 1921.*

Age on entering chest.	Chest No.	Date and result of examinations.									
		May 11.		May 21.		May 31.		June 6.		July 7.	
		Alive.	Dead.	Alive.	Dead.	Alive.	Dead.	Alive.	Dead.	Alive.	Dead.
Days.											
28	1	5	5	2	8	1	9	1	9	0	10
	2	3	7	1	9	0	10	.....	.....	.....	.....
	3	3	7	2	8	0	10	.....	.....	.....	.....
	4	6	4	6	4	3	7	3	7	0	10
21	1	6	4	5	5	1	9	0	10	.....	.....
	2	8	2	.....	.....	0	10	.....	.....	.....	.....
	3	8	2	3	7	1	9	0	10	.....	.....
	4	8	2	8	2	3	7	3	7	0	10
14	1	6	4	2	8	2	8	1	9	0	10
	2	6	4	1	9	0	10	.....	.....	.....	.....
	3	3	7	1	9	0	10	.....	.....	.....	.....
	4	5	5	1	9	0	10	.....	.....	.....	.....
11	1	7	3	2	8	0	10	.....	.....	.....	.....
	2	5	5	1	9	0	10	.....	.....	.....	.....
	3	9	1	1	9	1	9	0	10	.....	.....
	4	6	4	2	8	0	10	.....	.....	.....	.....
10	1	8	2	2	8	0	10	.....	.....	.....	.....
	2	4	6	0	10	.....	.....	.....	.....	.....	.....
	3	6	4	3	7	0	10	.....	.....	.....	.....
	4	6	4	2	8	0	10	.....	.....	.....	.....
9	1	3	7	1	9	1	9	0	10	.....	.....
	2	8	2	3	7	[1]1	9	0	10	.....	.....
	3	5	5	1	9	0	10	.....	.....	.....	.....
	4	8	2	5	5	0	10	.....	.....	.....	.....
8	1	2	8	0	10	.....	.....	.....	.....	.....	.....
	2	4	6	1	9	0	10	.....	.....	.....	.....
	3	4	6	2	8	0	10	.....	.....	.....	.....
	4	5	5	5	5	0	10	.....	.....	.....	.....
7	1	5	5	1	9	0	10	.....	.....	.....	.....
	2	6	4	1	9	1	9	1	9	0	10
	3	6	4	2	8	0	10	.....	.....	.....	.....
	4	3	7	0	10	.....	.....	.....	.....	.....	.....
5	1	1	9	1	9	1	9	1	9	0	10
	2	6	4	2	8	0	10	.....	.....	.....	.....
	3	6	4	4	6	0	10	.....	.....	.....	.....
	4	6	4	3	7	0	10	.....	.....	.....	.....
4	1	3	7	1	9	0	10	.....	.....	.....	.....
	2	6	4	4	6	0	10	.....	.....	.....	.....
	3	2	8	0	10	.....	.....	.....	.....	.....	.....
	4	4	6	0	10	.....	.....	.....	.....	.....	.....
3	1	3	7	0	10	.....	.....	.....	.....	.....	.....
	2	6	4	2	8	0	10	.....	.....	.....	.....
	3	5	5	[2]3	7	0	10	.....	.....	.....	.....
	4	3	7	0	10	.....	.....	.....	.....	.....	.....
2	1	3	7	1	9	0	10	.....	.....	.....	.....
	2	6	4	[1]1	9	0	10	.....	.....	.....	.....
	3	7	3	[2]3	7	1	9	0	10	.....	.....
	4	4	6	1	9	1	9	0	10	.....	.....
1	1	4	6	0	10	0	10	.....	.....	.....	.....
	2	6	4	1	9	0	10	.....	.....	.....	.....
	3	4	6	[2]1	9	0	10	.....	.....	.....	.....
	4	7	3	0	10	.....	.....	.....	.....	.....	.....

[1] Very active and normal in appearance.

[2] Larvæ inactive and doubtfully alive.

CONCLUSIONS.

Chests made of heartwood of red cedar (*Juniperus virginiana*), such as are found on the market, if in good condition as regards tightness, are effective in protecting fabrics from clothes-moth attack if certain precautions are taken to beat, brush, and, when possible, sun articles before placing them in the chest. The writers experimented with chests from the time of manufacture until they were 1 year old, and believe that chests will retain indefinitely their value as protectors against moth ravages provided they are cared for

properly. Since it is the odor of red cedar which is effective against moths it is recommended that in using cedar chests for the protection of clothing, fabrics, and furs, special care should be taken to prevent undue escape of the aroma from the chests. *The chests should remain tightly closed except when clothing is being removed or placed in them, and this procedure should be accomplished as rapidly as possible.* Aside from their value in killing moths, cedar chests are so tightly constructed that adult moths can not gain access to them except when they are open. This is not true of the average trunk or other receptacle in which clothing is stored.

Cedar chests exert no noticeable effect upon the adult moth or miller, the parent insect, which does no damage to clothing but which may lay eggs from which hatch the destructive larvæ, or worms. Moths that run or fly into chests, when open, may live as long as two weeks or even a month, and lay many fertile eggs.

Further, cedar chests are not effective against eggs, no matter whether the eggs are laid outside of the chest and accidentally introduced with the clothing, or whether they are laid in the chest itself. This is true regardless of the age of the eggs when they are subjected to the action of the chest. Imprisonment of adult moths and eggs in a cedar chest, however, is not an important consideration since the young larvæ promptly succumb to the effect of the chest and neither the moth nor the egg eats. However, cedar chests can not be depended upon to kill larvæ after they are 3 or 4 months old, or are from one-half to full grown. Some of the half to full-grown larvæ placed in chests have died, but their death may have been due to a normal mortality. The practical consideration is that many of them were not killed, but continued their development and matured as adults. These larger larvæ are capable of doing considerable damage within the chests though it is believed that their activities are somewhat retarded by the effect of the chests. The older the larvæ when they enter the chest the more resistant they are to this, until finally an age or size, not easily defined, is attained when larvæ are capable of withstanding chests and continue their feeding and development.

Cedar chests do kill young larvæ.—Larvæ hatching from eggs within the chests die in most instances within two or three days, and practically all die within two weeks. Larvæ hatching from eggs outside the chests and introduced into them in clothing do not die so quickly as larvæ hatching inside the chests because they are older, but the majority of such larvæ, which soon show a tendency not to feed, die during the first and second weeks, although some may live longer. Two larvæ, 2 days old when placed in a chest, lived for about 35 days; such resistance, however, is the exception rather than the rule.

It is important that articles intended for storage in cedar chests should be most painstakingly cleaned, beaten, brushed, and sunned whenever practicable to remove or kill as many of the moth eggs and larvæ as possible. Special attention should be given to brushing all seams, creases, and pockets. Clothing thoroughly brushed and sunned should harbor none of the larger or older moth larvæ and very few, if any, eggs and young larvæ. Such clothing if stored at once in good cedar chests should be protected from moth ravages,

for the young larvæ that might be present, or those that might hatch from eggs present in the clothing, would be killed before they could cause serious damage.

Although cedar chests may be regarded as protectors against clothes moths, attention is called to the fact that a chest of ordinary wood, if as tightly constructed, would be just as effective, provided the clothing were as thoroughly cleaned, brushed, and sunned, and from 1 to 2 pounds of good grade naphthalene were packed within.

Woolen garments freshly cleaned and thoroughly brushed will be well protected if tightly wrapped with naphthalene in several thicknesses of ordinary paper. Many persons protect their clothing by carefully cleaning and brushing just before wrapping in paper. In wrapping with paper special attention should be given to turning back the paper at the ends of the bundle that no opportunity to gain access be left for the moths.

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